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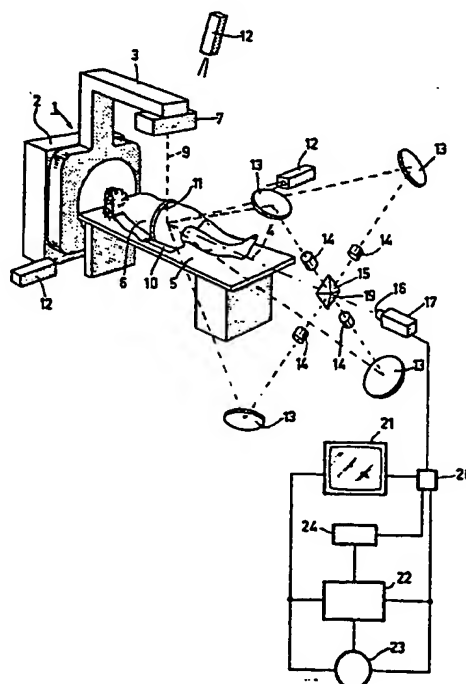
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(54) Contour measuring device.

(57) A device for measuring object contours (11) comprises a mirror system with at least three mirrors (13) for reading a contour marked preferably by means of several light sources (12). The contour detection system comprises lenses (14) which render the measurement angle-independent and a collecting optical system (15). The collecting optical system (15) forms a single faithful image from the sub-images from the respective mirrors (13), which is then imaged, for example, on a television camera (17). The device furthermore comprises an image display device (21) and means (24) for the comparison of contours.



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"Contour measuring device".

The invention relates to a device for measuring object contours in which a contour of the object is marked and the marked contour is sensed and measured optically.

A device of this kind is known from GB 1,328,033.

5 In a device described therein, a light spot is projected onto the object and a probe is automatically adjusted by the detection of reflected light so that the contour can be read during a rotation of the source and the detector about the object. It has been found that this device does
10 not operate satisfactorily in practice. For example, for medical applications the measurement requires too much time and must be separately performed in advance. Differences in reflection from a surface and excessively abrupt angular variations also cause difficulties. The
15 discrete measurement point form of notation required in this device is also considered to be a drawback.

The invention has for its object to mitigate these drawbacks and to provide a device for measuring object contours in which a complete contour can be on-line
20 measured, even in the case of an apparatus in operation. To achieve this, a device of the kind set forth in accordance with the invention is characterized in that the device for the optical measurement of a contour comprises a mirror system and a detection system for the formation of a
25 single image of the marked contour on the input surface of an image sensing device.

In an apparatus comprising a device in accordance with the invention, a closed contour can always be displayed on-line on an image display device, without disturbing the measurement or treatment being carried out by
30 the apparatus. Thus, an accurate readily reproducible and fast contour measurement can be realized which enables further automatic processing to be simplified.

In a preferred embodiment in accordance with the invention, the optical system comprises, for each different viewpoint a mirror with a lens for forming an angle-corrected sub-image on an optical collecting member in order to form a faithful summed image on, for example, a target of a television camera tube. The optical collecting member may be constructed as a pyramidshaped mirror or as a prism with an entrance side face for each of the mirrors. A lens is arranged preferably, between the collecting member and each of the mirrors, but may alternatively be arranged between the collecting member and the image sensing device so that the sub-images are imaged and combined to form a focussed, continuous and faithful image on the input screen of the image pick-up device.

In a preferred embodiment, the contour to be measured is illuminated by means of light projectors, the number and distribution along a circumference of which may be chosen so that substantially the entire contour will nevertheless be illuminated, even when one of the projector is shielded. A similar distribution may be chosen for the mirrors.

When a computer is included in a device in accordance with the invention, any desired contour can be recorded and used as a reference, for example, to compensate for movements of the object, to prevent a collision between the therapeutic or measuring equipment and the object, to reposition an object, and to monitor any variations in object shape, for example, regression during the irradiation of a patient.

Some preferred embodiments in accordance with the invention will be described in detail hereinafter with reference to the drawing. The single figure of the drawing shows a device in accordance with the invention for measuring body contours for controlling radiation therapy. In a radiation therapy apparatus, for example, a linear accelerator as described in Journal of Applied Medicine, Vol. 5, No. 6, pages 445-454, the actual linear accelera-

tor comprises a fixed section 1 which is provided with a displacement mechanism for a gantry 2 with an arm 3. The arm 3 is rotatable about a patient 6 arranged on a patient support 5. The patient is irradiated by a beam along a line 9 from a radiation source 7. To achieve this, the table may be provided with an opening 10 in the region of the beam path. By rotating the source about the patient, an anomaly inside the patient can be irradiated while applying a minimum radiation dose to surrounding organs and to the skin of the patient. In order to optimize the irradiation, it is necessary to determine the exact location of the anomaly and to correct for any displacement, and therefore the exact local contour 11 must be known. In order to measure the contour, in accordance with the invention light sources 12 which together illuminate the entire contour 11, are mounted, for example, on the walls of the room in which the accelerator is arranged. For the sake of clarity, the drawing shows only three light sources; this number may be sufficient for illuminating a closed contour, but it may be advisable to use a larger number of light sources. In the case of local shielding, for example, by additional equipment or by an operator, the entire contour can then remain illuminated; the distribution of the light sources over the circumference can also be adapted to the shielding arrangement which is expected to occur most frequently.

In order as far as possible to prevent shielding, notably by operating personnel, it is advantageous to arrange the light sources on the side of the fixed section of the irradiation apparatus. However, this may have disadvantages because of shadows formed by the patient himself; for example, in the case of a contour of the throat, a shadow can readily be formed by the chin. This is avoided by arranging the light sources on the side away from the fixed section of the irradiation apparatus. If both advantages are to be utilized, use can be made

of a twin system, so that, for example, a series of mirror systems is mounted on or near the fixed section 1 of the apparatus, and a further series is mounted remote therefrom. Reading can then take place from two directions at mutually equal angles. If a single optical collecting member is used, the optical beam path length must be made the same for both directions in order to obtain an unambiguous image. The device preferably comprises at least three mirrors 13, and the embodiment shown comprises four mirrors. These mirrors may be secured to the walls of the room in such an arrangement that the entire contour can be seen from the combination of mirrors. The positions of the mirrors need not correspond to those of the light sources, but such correspondence need not be excluded. Each of the mirrors has associated with it a lens 14 which images that part of the contour line which is reflected by the mirror onto the entrance target 16 of a television camera 17 via an optical collecting member 15. The optical axis of the television camera and an optical centre 19 of the collecting member coincide with an axis 4 about which the source rotates and which is usually referred to as the isocentric axis. The television camera is preferably connected, via a switching device 20, to a television monitor 21 for displaying the contour. A contour thus sensed and measured can be stored in digital form in the memory of a computer 22 or in analog form on a magnetic tape or on a disk 23. Once a contour of an object has been sensed, measured and stored, it can be used as a reference contour and a simple indicator 24 then suffices to signal any discrepancies occurring. If desired, the reference contour and a currently measured contour can be displayed together on the monitor. This enables a direct visual observation to be made of any discrepancy in the latest contour and, for example, an undesired shift of, for example, an arm of the patient can be corrected immediately. It is then

also simple to add an automatic switch-off device for the irradiation apparatus which responds to a predetermined discrepancy in the contour. From a sensed and measured contour a circum scribed circle can be calculated whose
5 coordinates can be used for controlling an anti-collision device included in the apparatus, which maintains a minimum clearance between the patient and the relevant parts of the patient support or the equipment used during therapy, for example, a detector or radiation shield. An identified
10 and recorded contour can also be used for repositioning the patient, for example, for repeating a course of radiation therapy.

For the present embodiment it has been assumed that the light sources and the mirrors each occupy a
15 fixed position. If the mirrors are secured to a rotating part, for example, the arm 3, it is desirable that the lenses, the collecting member and the camera should also be secured thereto. In that case, the light sources may be arranged to be stationary or to be rotatable, as
20 desired. In the case of an arrangement involving camera rotation, it may be advantageous to apply image rotation to the monitor display, so that the orientation of the picture on the screen remains fixed. In order to reduce the disturbing effect of ambient light on the measurement,
25 use can be made of light sources generating light having a specific wavelength to which the measuring device is adapted. The detection device of the described embodiment comprises a television camera. Instead of a television camera, use can be made of an alternative image pick-up
30 device which may be cheaper because its resolution need not be very high. A suitable detector in this respect could be a self-scanning semiconductor detector.

The invention has been described with reference to a medical therapeutic apparatus, notably a linear
35 accelerator. It will be apparent that the invention has a much wider field of application, for example, other medical equipment where the separate measurement of a contour is important, for example, in scanners in cobalt irradiation

apparatus, neutron irradiation apparatus and the like.

The invention can also be successfully used for non-medical applications, such as for the measurement of objects or workpieces to be treated and for determining

5 shape variations caused in objects by physical effects. A device in accordance with the invention can also be used for the fast and accurate testing of workpieces with respect to given dimensions, and the profiles of moulds used for moulding, can be simply determined and recorded.

10 In the foregoing, a contour marked by light sources has been assumed. Even though this is a convenient method, use can alternatively be made of a contour marked in a different manner, for example, by the application of a dye, a fluorescent substance or a series of luminescent
15 devices. In that case the scanning section may still have the described construction. Therefore, the invention can also be used for sensing and measuring contour marks which already form part of an object such as a workpiece or a mould.

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[CLP.1]

1. A device for measuring object contours in which a contour of an object is marked and the marked contour is sensed and measured optically, characterized in that the device for the optical measurement of a contour comprises a mirror system and a detection system for the formation of a single image of the marked contour on the input surface of an image sensing device.
2. A device as claimed in Claim 1, characterized in that the device includes means for marking a contour comprising at least three light sources which are situated to the side of an object to be measured.
3. A device as claimed in Claim 1 or 2, characterized in that the mirror system comprises at least three mirrors, each of which has associated with it a lens system for forming an angle-corrected faithful sub-image of a contour portion on an optical collecting member which forms from the three or more sub-images a focussed, faithful image of the contour on the image-forming device.
4. A device as claimed in Claim 3, characterized in that the read-out mirror system is of duplicate construction with mutually equal reading angles and mutually equal optical beam path lengths to a common optical collecting member.
5. A device as claimed in Claim 1, 2 or 3, characterized in that the image-forming device comprises a television camera with a monitor.
6. A device as claimed in Claim 4, characterized in that a video memory is associated therewith.
7. A device as claimed in Claim 4 or 5, characterized in that an analog-to-digital converter and a computer are associated therewith for the recording and comparison of contours.

8. A device as claimed in any one of the preceding Claims, characterized in that the detection system is specifically sensitive to a spectral range of radiation by means of which the marking is effected.

5 9. A medical irradiation apparatus comprising a device for measuring object contours as claimed in any one of the preceding Claims.

10 10. An apparatus for a treatment of work pieces, comprising a device for measuring object contours as claimed in any one of Claims 1 to 7.

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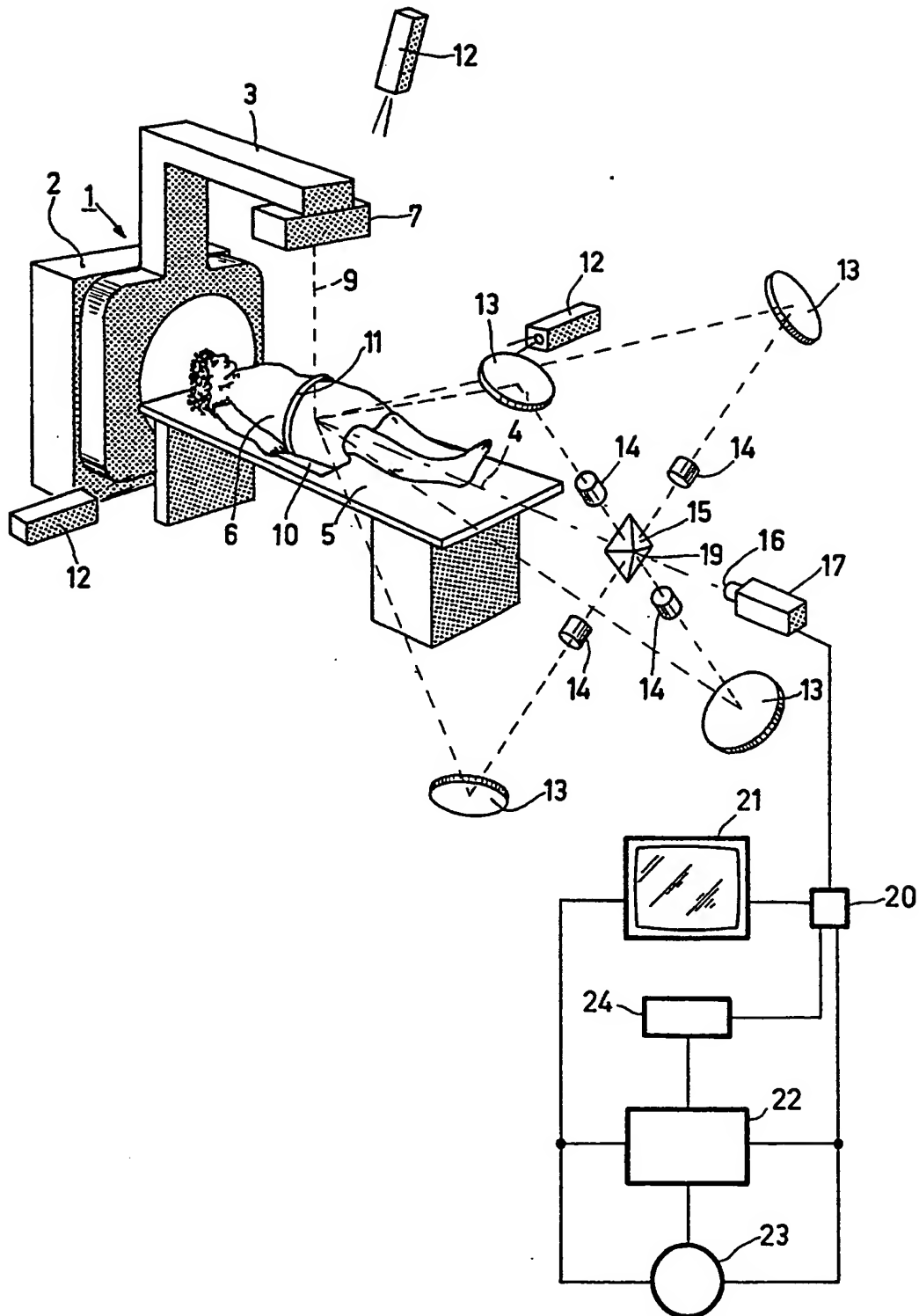
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EUROPEAN SEARCH REPORT

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Application number

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 7)
X	PHYSICS IN MEDICINE AND BIOLOGY, vol. 20, no. 4, July 1975, pages 627-631, Bristol (GB); S.C.LILLICRAP et al.: "A device for the automatic recording of patient outlines on the treatment simulator". *Pages 627-631*	1,7-10	A 61 B 5/10 A 61 B 6/08 G 01 B 11/24
A	--- GB-A- 692 923 (EASTMAN KODAK COMP.) *Page 1, lines 29-43; page 2, lines 56-118; page 3, lines 27-53; figures 1,2*	1-3	
A	--- NL-A-7 605 264 (ELECTRORAIL N.V.) *Page 1, line 24 - page 2, line 34; page 3, lines 18-37; figure 1*	1,5,6,9,10	
A	--- US-A-3 950 096 (J.P.AESCHLIMANN et al./ ALCYON ELECTRONIQUE & PHYSIQUE S.A.) *Abstract; column 1, lines 35-60; column 2, lines 8-24; column 3, line 18 - column 4, line 7; figures 1-4* & FR - A - 2 242 663	1,2,5,7-10	
A	--- US-A-4 242 587 (C.LESCRENIER) *Abstract; column 4, line 1 - column 6, line 35; figures 1-6*	1,2,9	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 7)
			A 61 B 5/10 A 61 B 6/08 G 01 B 11/24 G 01 C 7/00 G 01 C 11/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15-07-1982	Examiner RIEB D.K.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		& : member of the same patent family, corresponding document	



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DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
D, A	GB-A-1 328 033 (PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LTD.) *Page 1, lines 40-72; page 2, line 5-79; page 2, lines 103-126; figures 1,2* -----	1,7-10
		CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
The present search report has been drawn up for all claims		
Place of search THE HAGUE	Date of completion of the search 15-07-1982	Examiner RIEB D.K.
CATEGORY OF CITED DOCUMENTS		
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